

# UNCLASSIFIED

AD NUMBER	
AD038789	
CLASSIFICATION CHANGES	
TO:	unclassified
FROM:	confidential
LIMITATION CHANGES	
TO: Approved for public release; distribution is unlimited.	
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; APR 1954. Other requests shall be referred to Office of Naval Research, Washington, DC.	
AUTHORITY	
30 apr 1966, DoDD 5200.10; onr ltr, 13 sep 1977	

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED  
AND CLEARED FOR PUBLIC RELEASE  
UNDER DOD DIRECTIVE 5200.20 AND  
NO RESTRICTIONS ARE IMPOSED UPON  
ITS USE AND DISCLOSURE.

DISTRIBUTION STATEMENT A

APPROVED FOR PUBLIC RELEASE;  
DISTRIBUTION UNLIMITED.

# UNCLASSIFIED

---

## AD \_\_\_\_\_

*Reproduced  
by the*

ARMED SERVICES TECHNICAL INFORMATION AGENCY  
ARLINGTON HALL STATION  
ARLINGTON 12, VIRGINIA



DECLASSIFIED  
DOD DIR 5200.9

---

---

# UNCLASSIFIED

# Armed Services Technical Information Agency

Because of our limited supply, you are requested to return this copy WHEN IT HAS SERVED YOUR PURPOSE so that it may be made available to other requesters. Your cooperation will be appreciated.

# AD

# 38789

NOTICE: WHEN GOVERNMENT OR OTHER DRAWINGS, SPECIFICATIONS OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE U. S. GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

Reproduced by  
**DOCUMENT SERVICE CENTER**  
KNOTT BUILDING, DAYTON, 2, OHIO

# CONFIDENTIAL

**NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE  
NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING  
OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794.  
THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN  
ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.**

38 789

AD NO.

ASTA FILE COPY

CONFIDENTIAL

General Mills, Inc.  
Mechanical Division

ENGINEERING RESEARCH & DEVELOPMENT  
DIVISION

201 EAST WASHINGTON AVENUE  
MINNEAPOLIS 11, MINN.

CONFIDENTIAL

544A 48748

This document consists of 12 pages and is number 7  
of 30 copies, series B, and the following 4 attach-  
ments.

Fig 1, 2, 3  
appendix

CONFIDENTIAL

PROGRESS REPORT

Contract No. Nonr 875(00)  
Annex XII  
April 1, 1954

Prepared for  
The Office of Naval Research  
Washington 25, D. C.

Report No. 1289

Prepared by: F. Bartholomew

Approved by:

  
Clelio Brunetti, Director

GENERAL MILLS, INC.  
Mechanical Division  
ENGINEERING RESEARCH AND DEVELOPMENT  
2003 E. Hennepin Ave.  
Minneapolis 13, Minn.

CONFIDENTIAL

RAAA

10710

CONFIDENTIAL

TABLE OF CONTENTS

	<u>Page No.</u>
I. ENGINEERING STUDY . . . . .	1
A. Theory of the Super-pressure Balloon . . . .	1
B. Derivation of Strength Specifications . . . .	3
C. Materials . . . . .	5
II. BALLOON CONSTRUCTION . . . . .	8
A. Experimental Designs . . . . .	8
B. Construction Schedule . . . . .	8
C. Development of Electronic Sealer for Saran . . . . .	8
III. EXPERIMENTS . . . . .	10
A. Executed . . . . .	10
B. Planned . . . . .	10
IV. FINANCES . . . . .	12

APPENDIX

REPORT OF FLIGHT 1108

CONFIDENTIAL

CONFIDENTIAL

## I. ENGINEERING STUDY

### A. Theory of the Super-pressure Balloon

The objective of this project is to investigate all aspects of a balloon which, by containing its lifting gas at a pressure greater than the ambient pressure, is able to float at essentially a constant level in the atmosphere without the expenditure of ballast. The requirements for such a balloon which would enable it to float from one day to the next, without deviating greatly from its assigned altitude, are of special interest. If possible, such a balloon is to be built and flown.

The fundamental mechanism involved in the functioning of a super-pressure balloon, when it floats from day to night without requiring ballast expenditure, is one of storage of super-heat energy. In a balloon with an open appendix, the energy received by the lifting gas in the form of heat during the day is dissipated in two ways:

1. After super-heat equilibrium conditions have been established, the balloon loses as much heat by conduction, convection, and re-radiation as it receives.

2. While the gas is warming to the equilibrium temperature, the excess of heat energy received, over and above that being lost, is expended in the expansion of the gas which, being unrestrained, leaves the balloon.

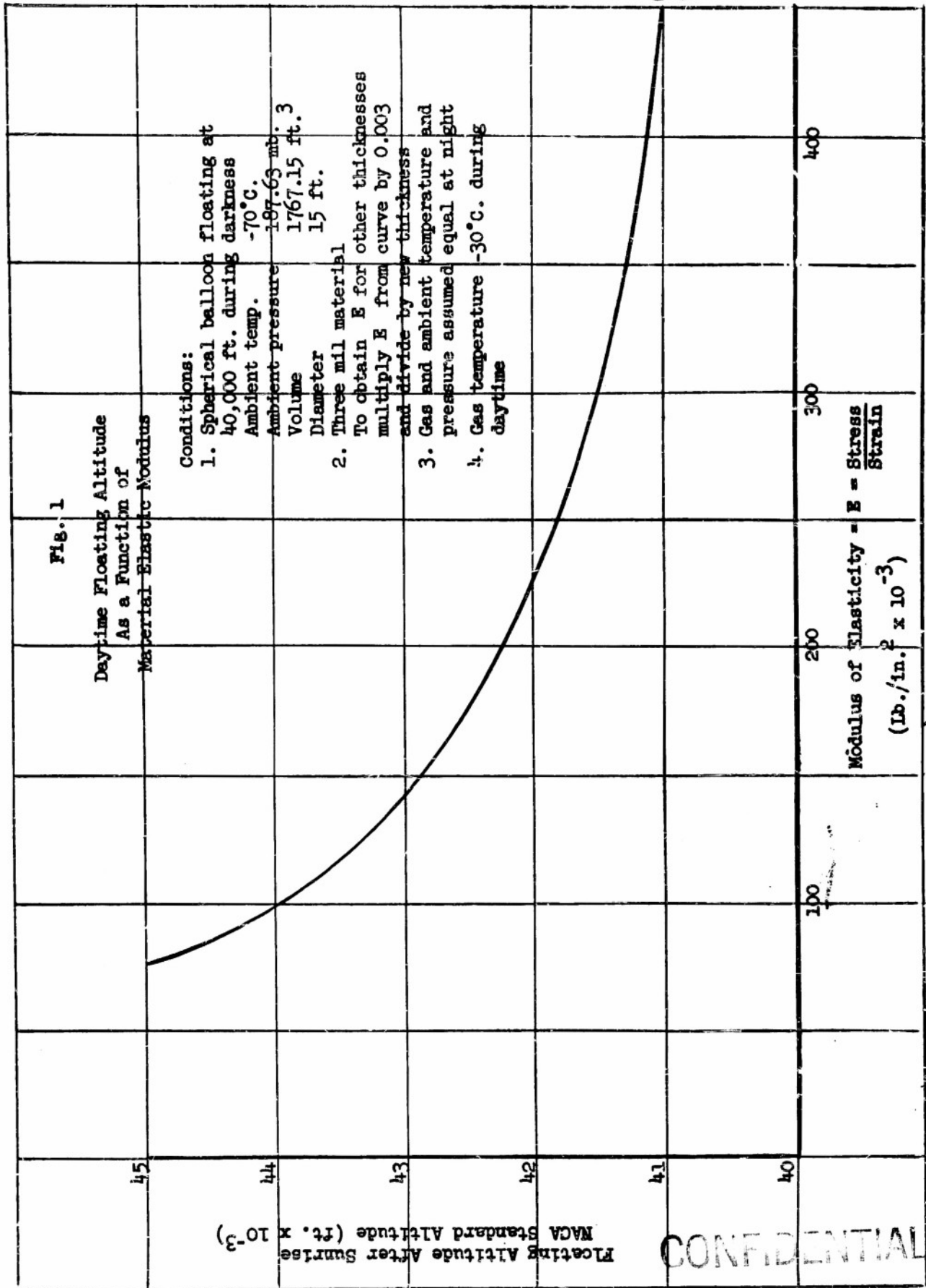
The functioning of a super-pressure balloon differs at this point from that of an open appendix balloon. The super-pressure balloon retains in the elastic strength of its walls the energy mentioned in 2. above. At sunset the energy is dissipated through cooling, but so long as the internal pressure of the balloon is not reduced to zero, the balloon will merely seek a slightly lower floating level for night-time flight.

The parameters involved here are Tensile Modulus and Variation in Altitude. Figure 1 shows the Modulus which is required of a material for variations of altitude over a range extending from 40,000 to 45,000 ft. Some descent at sunset is necessary, for there is no material with zero elongation under stress, but for flights which can tolerate a few thousand feet of variation from night to day, the super-pressure balloon is theoretically a possible solution.

The published Moduli for materials being studied is shown in Table I. It must be remembered that these figures are based upon tensile strengths at room temperature. As yet, no values are available for stress strain relationships at the temperatures experienced in the stratosphere but this information will be obtained under this project (see III, Experiments, below).

CONFIDENTIAL

CONFIDENTIAL



CONFIDENTIAL

CONFIDENTIAL

TABLE I

	Mylar	Saran	
		Q853.1	517
Tensile Strength	17,000-25,000	9,000-12,000	7,000-15,000
Tensile Modulus	450,000-600,000	21,000	36,000
Elastic Limit	13,000	Undetermined to date	
Modulus of Elasticity	260,000	Undetermined to date	

Note: All values are in lb./in.<sup>2</sup> and are those for room temperature.

CONFIDENTIAL

CONFIDENTIAL

The flight performance to be expected of a super-pressure balloon floating from one day to the next proceeds as follows:

Assume the balloon is flown sealed, that is, once inflated and given its free lift, the appendix is closed, and no valve or other provision for releasing the gas is provided. The balloon is launched at night (though not necessarily so) and rises to its floating altitude where its free lift gas develops an internal pressure of 4 or 5 inches of water. Such pressure results in some slight stretching of the balloon's walls. This stretching affects two things: (1) the equilibrium altitude (since it affects the volume), and (2) the tensile strength required in the walls (since the balloon's radius is affected). At sunrise, the radiation incident upon the balloon heats both the balloon and the contained gas causing (1) increased temperature and pressure of the gas, (2) increased temperature and hence decreased tensile strength of the balloon walls. Together, these factors combine to cause some additional expansion of the balloon, which therefore rises to a new equilibrium altitude. With walls of sufficient strength, the balloon then floats at this maximum altitude where there is both a buoyant equilibrium and a heat balance.

At sunset, the balloon and gas cool and contract, but if the elastic limit of the material has not been exceeded, and if gas has not been lost through leakage, the super-pressure is maintained and the balloon never becomes slack. As it descends, instead of reducing its volume proportionately to the increasing atmospheric pressure, as an open appendix balloon does, it reduces its volume solely as a result of the elastic properties of its walls which are experiencing a decrease in tension. When it reaches the level where buoyant and heat equilibrium are again established, it levels off and floats through the night. With no gas loss other than diffusion, this lower level will be very nearly the same as that of the previous night.

If the necessary free lift develops too great internal pressure in a sealed balloon, a pressure relief valve can be used, or the balloon's appendix can be automatically closed after some of the free lift has been expelled.

Calculations show that diffusion through Mylar, for example, is so slight that, if the material can stand pressures developed by temperature changes 2° greater than those brought about by superheat, the extra gas contained would last for approximately 100 days before the balloon became slack at sunset. The problem, then, is to design and build a balloon which can survive one sunset. Such a balloon should be capable of flights of extended duration.

#### B. Derivation of Strength Specifications

As described in a letter to ONR dated 26 February in which was reported the first month's work under this project, two types of balloons

CONFIDENTIAL

CONFIDENTIAL

are being considered: (1) those with a spherical shape, and (2) those with the shape of a double elastica which have acquired the name of "Onion" balloons.\*

The feature in each of these balloons which is important from a material strength standpoint is the radius or the radii of the balloon or its sections. In the spherical balloon it would be expected that the material would be stressed equally in all directions. In the Onion shape, the advantage gained is that of removing the circumferential stress. Only the radii in planes passing through the vertical diameter are significant.

# 1. Superheat

For purposes of calculation, it was assumed that superheat would be 40°C., which is twice the maximum superheat of a 1.5 mil polyethylene taped balloon at 60,000 feet. To arrive at a single maximum tensile stress figure, it was assumed also that the volume remains constant. This would mean that the balloon would not change its floating altitude from day to night. Since all materials have some elongation under stress, this condition will not be found, but it is a conservative assumption in arriving at a tensile figure for a given superheat. (See Fig. 1 for the effect of elastic modulus in varying the altitude). Assuming a floating level of 200 millibars, and an ambient temperature of -70°C.:

$$T_1 = 243^{\circ}\text{K} = \text{temperature of helium before sunset}$$

$$T_2 = 203^{\circ}\text{K} = \text{temperature of helium after sunset}$$

$$P_1 = ? \quad \text{absolute pressure within the balloon before sunset in millibars}$$

$$P_2 = 200 \text{ millibars} = \text{the ambient pressure}$$

$$P_1 = \frac{T_1}{T_2} (P_2) = 240 \text{ millibars}$$

That is, the internal pressure required to prevent a slack balloon at night would be 40 millibars if the balloon's volume did not increase under pressure. Forty millibars is 0.582 lb./in.<sup>2</sup> or 16.2 inches of water.

---

\*The Onion balloon is made from a cylinder of material gathered at both ends, with the gore length being related to the diameter by the following equation:  
 $D = .764L$

CONFIDENTIAL

CONFIDENTIAL

## 2. Material Specifications

Using a spherical shape for reference:

$$Pr = 2st$$

Where  $P$  = internal pressure in  $\text{lb./in.}^2$

$r$  = radius of balloon in inches

$s$  = tensile strength in  $\text{lb./in.}^2$

$t$  = thickness in inches

For purposes of convenience, the unit  $st = \text{lb./in.}^2 \times \text{in.} = \text{lb./in.}$  is sometimes used.

The requirements for the two sizes under consideration follow:  
(throughout, the larger size of either the sphere or Onion is rated to carry 10 lbs. at 40,000 ft., and the smaller size to carry 3 lbs. at the same level).

### a. A Fifteen Foot Sphere

Minimum Tensile strength =  $st = 27 \text{ lb./in.}$

Maximum material weight =  $0.0258 \text{ lb./ft.}^2 = 3.72 \text{ oz./yd.}^2$

### b. A Ten Foot Sphere

Minimum Tensile Strength =  $st = 18 \text{ lb./in.}$

Maximum material weight =  $0.0171 \text{ lb./ft.}^2 = 2.48 \text{ oz./yd.}^2$

### c. Onions

Volume of  $1800 \text{ ft.}^3$  (17.6' dia.):

Assumed minimum tensile:  $27 \text{ lb./in.}$

Maximum material weight  $0.0147 \text{ lb./ft.}^2 = 2.12 \text{ oz./yd.}^2$

Volume of  $600 \text{ ft.}^3$  (12.1' dia.):

Assumed minimum tensile:  $18 \text{ lb./in.}$

Maximum material weight  $0.011 \text{ lb./ft.}^2 = 1.58 \text{ oz./yd.}^2$

## C. Materials

In all cases, the only available information as to tensile strength, elastic properties, permeability, etc., has been taken from the performance of the material at temperatures warmer than those which it will experience if used in a balloon. Some data are available on the variation of these properties in polyethylene down to low temperatures, and data for Mylar give

CONFIDENTIAL

CONFIDENTIAL

an indication of what is to be expected, but there is nothing available for Saran as yet, except the cold brittleness tests which have been performed under this project. Suitable equipment to perform these tests is being built in General Mills' laboratory, and the information will be obtained as soon as possible. Since flight tests would be necessary in any case, these are going ahead at the same time (see III, Experiment).

1. Saran Q 53.1

Rated tensile strength of -12,000 psi (corrected from earlier report) is estimated at stratospheric temperatures to increase to at least 15,000 psi (this will be checked). For 27 lb./in., 1.8 mil material would be required. Three mil material is being used. Its weight is 0.027 lb./ft.<sup>2</sup>. Tensile modulus is low at room temperature, being 21,000 lb./in.<sup>2</sup>.

2. Saran-Polyethylene Laminate

At this writing, there has been no word from Dobeckmun Co. advising us whether or not they will be able to provide us with a sample of this lamination.

3. Mylar

Rated with a yield point of 13,000 psi. at room temperature, and an Elastic Modulus of 260,000 lb./in.<sup>2</sup> within that elastic limit, Mylar is well above Saran in every characteristic except sealability. (The yield point of Saran is unknown as yet.) For 27 lb./in., only one mil Mylar may be required. Its weight is 0.0076 lb./ft.<sup>2</sup>. This allows Mylar to be laminated with polyethylene to provide a good sealing method (for the Onion shape) without exceeding the limit of 0.0147 lb./ft.<sup>2</sup>.

4. Mylar-Polyethylene Laminate

Dobeckmun has run 200 yards of 2 mil polyethylene extruded onto one mil Mylar, and delivery is expected about April 2. No adhesive was necessary, and a good bond was obtained. Preliminary laboratory tests have been run on a one-yard sample. At -75°C., the Mylar showed a no-shatter "8" tear, while some small shatter lines were visible in the polyethylene. De-lamination also occurred around the rupture at that temperature.

5. Nylon Envelope

Using polyethylene as a gas barrier in a nylon envelope, a nylon material weighing no more than 2.6 oz./yd.<sup>2</sup> and with a tensile strength of at least 27 lb./in. is needed for the 15 ft. sphere. The first fifteen foot spheres (2) have been made from material weighing 2.5 oz./yd.<sup>2</sup> and having a tensile of 160-180 lb./in. The first (2) nylon spheres 10 feet in diameter have been made from material weighing 1.1 oz./yd.<sup>2</sup> and having a tensile of 50 lb./in. Here a weight of 1.4 oz./yd.<sup>2</sup> could be tolerated, and a strength of 18 lb./in. was required.

CONFIDENTIAL

CONFIDENTIAL

When rubber balloons are used as the gas barrier, the weight limitations of the envelopes are somewhat less restrictive, but the envelopes are designed for either use and, therefore, meet the requirements established by a polyethylene bladder.

6. Polyethylene Impregnated Fiberglass

An improvement in design and in ease of manufacture over the nylon balloons described above appears possible through the use of a material discovered during the last month. Specimens of fiberglass impregnated with polyethylene have been heat-sealed together with a lap seal so successfully that, although the fiberglass has tensile strength many times that of polyethylene, the material has broken before the seal in tensile tests conducted here. Fiberglass with a weight of 2.4 oz./yd.<sup>2</sup> and a tensile strength of 90 - 130 lbs./in. is available and has been ordered for laminating by Dobeckum Company. Balloons of this material would be sturdy enough to withstand several flights.

CONFIDENTIAL

CONFIDENTIAL

## II. BALLOON CONSTRUCTION

### A. Experimental Designs

#### 1. Spherical Balloons

##### a. Gored plastic spheres

- (1) Saran
- (2) Saran laminated with polyethylene to improve Saran's cold brittleness temperature (Saran seal).

##### b. Gored nylon envelope containing a gas barrier.

- (1) Polyethylene gas barrier.
- (2) Rubber balloon gas barrier.

##### c. Gored sphere of fiberglass fabric impregnated with polyethylene (heat sealed).

#### 2. Onion-shaped (double elastica) Balloons

##### a. Saran

##### b. Saran laminated with polyethylene to improve Saran's cold brittleness temperature (Saran or polyethylene seal).

##### c. Mylar laminated with polyethylene to provide a good seal.

### B. Construction Schedule

Balloons of type 1.b above are ready for assembly, the last components having been completed on 29 March. It is expected that flights with these balloons will be made shortly after April 1 (see III, Experiments, below).

The next type of balloon to be tested will be 2.c., making use of the Mylar-polyethylene laminated film which is expected by April 2.

Balloons consisting of Saran will be delayed until suitable sealing equipment can be built (see II.C., below), or until the Saran-polyethylene laminate is proved feasible and type 2.b. can be made.

Balloons employing the polyethylene impregnated fiberglass can be made as soon as the material is received from Dobeckmun Co., which will be some time in May.

### C. Development of Electronic Sealer for Saran

During the week of March 3, J. Kaliszewski and F. Bartholomew made a trip to the East Coast to visit the Singer Sewing Machine Company to discuss mechanical modifications in their electronic seamer which would accomplish

CONFIDENTIAL

CONFIDENTIAL

mechanically the high quality continuous seal which had been made manually at General Mills. At the same time, an investigation of all other types of electronic sealing equipment was pursued.

Singer Sewing Machine Company

Mr. H. G. Klawunn of Singer Sewing Machine Company is their expert on the electronic seamer. His office and experimental laboratory is at 561 Broadway, New York City. He was pessimistic as to the possibility of obtaining a good seal with Saran through modification of the mechanical design, but agreed to experiment with seals on a sample of Saran which was left with him. The idea of redesigning the mechanism of the Singer Sewing Machine Sealer was not pressed any further at that time because, en route to New York, a visit to the Dow Chemical Company at Midland, Michigan, had revealed a machine with a better seal and one more readily adaptable to balloon manufacture.

Dow Chemical Company

The Lap-Seal Tuber No. 124, developed by Dow for the purpose of making tubing out of sheet material, requires only a modification in its mounting to make it capable of sealing Saran in the manufacture of balloons. The seal is now made as the material is drawn past the electrodes, riding over the lower one, which is in the form of a plate, and beneath the upper one which is a small bar resting on the film. A continuous seal is made at a rate of 55 - 60 ft./minute. By rotating the position of the electrodes and folding devices through ninety degrees, and by propelling the sealer instead of the material, the Dow Lap Seal Tuber can be adapted to balloon production.

Components for the r. f. generator cost \$187.11, and it is estimated that it would take one man two weeks to assemble it. The mechanical engineering problem of designing mountings, gear trains, folding devices, etc. will be undertaken if the low temperature tensile tests are favorable as soon as authority to do so has been obtained. Mr. Fred Dulmage and Mr. Jack Gibbs of Dow have given General Mills a complete set of drawings and photographs of No. 124 to work from.

Other sealing equipment was investigated at the Mayflower Electronic Devices, Inc., 6014 Hudson Blvd., West New York, New Jersey, and the Radio Receptor Co., 84 North 9th St., Brooklyn 11, New York, without finding any improvement over the Dow sealer.

CONFIDENTIAL

CONFIDENTIAL

### III. EXPERIMENTS

#### A. Executed

##### 1. Laboratory

###### a. Material Testing

###### (1) Saran Q853.1

Cold brittleness -55° to -60°C.

###### (2) Mylar-polyethylene laminate

Cold brittleness below -75°C.

###### (3) Polyethylene impregnated fiberglass

Lap heat seal tested for strength. The material yielded, without the seal's breaking, at 56 lb./in. and at 50 lb./in. (This was a sample of lighter weight than that ordered from Dobeckmun Co.)

###### b. Relative Superheat

A laboratory test to compare the superheat to be expected from various balloon materials was performed. An infrared lamp was focused on helium-filled balloons of uniform size, each being subjected individually to the radiation at a uniform distance. The temperature rise was sensed by a thermocouple within the balloon, and the effect upon the thermocouple itself was calibrated out in the comparison of values shown in Fig. 2. The variation of temperature rise in a polyethylene balloon, as the thickness of the film is increased, is shown in Fig. 3.

##### 2. Flight

An experiment performed on a flight with a 25 foot balloon in an effort to gain some qualitative knowledge of radiation conditions at night is described in Report No. 1280 in the Appendix.

#### B. Planned

##### 1. Laboratory

A portable cold box is being prepared for use with the tensile tester, in order to evaluate the tensile strength, elastic limit, and modulus of the materials under consideration at the lower temperatures which they will experience if they are used in balloons.

CONFIDENTIAL

CONFIDENTIAL

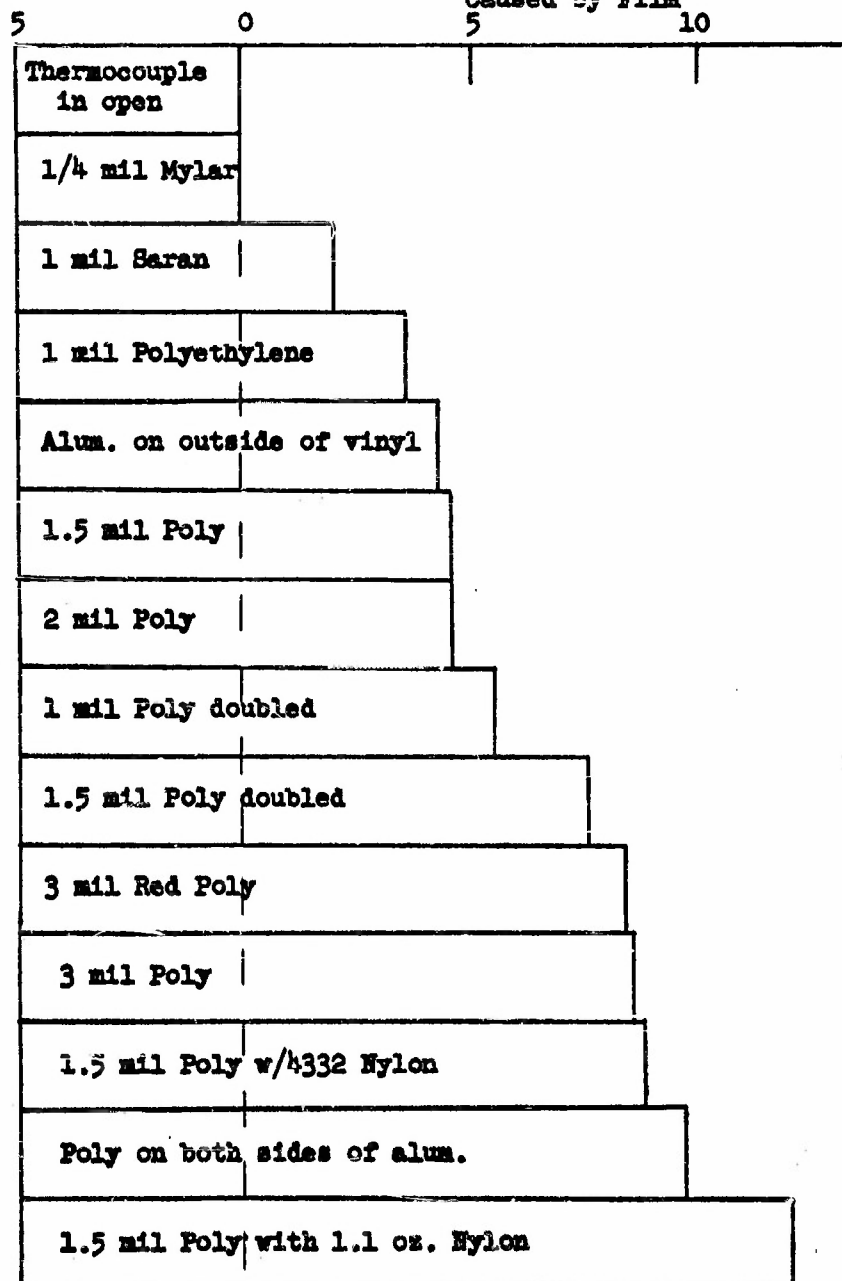
Fig. 2

TEMPERATURE RISE IN HELIUM FILLED  
SAMPLE BALLOONS UNDER INFRA RED  
HEAT LAMP

Absorption by  
Thermocouple

Temperature Rise (°F)

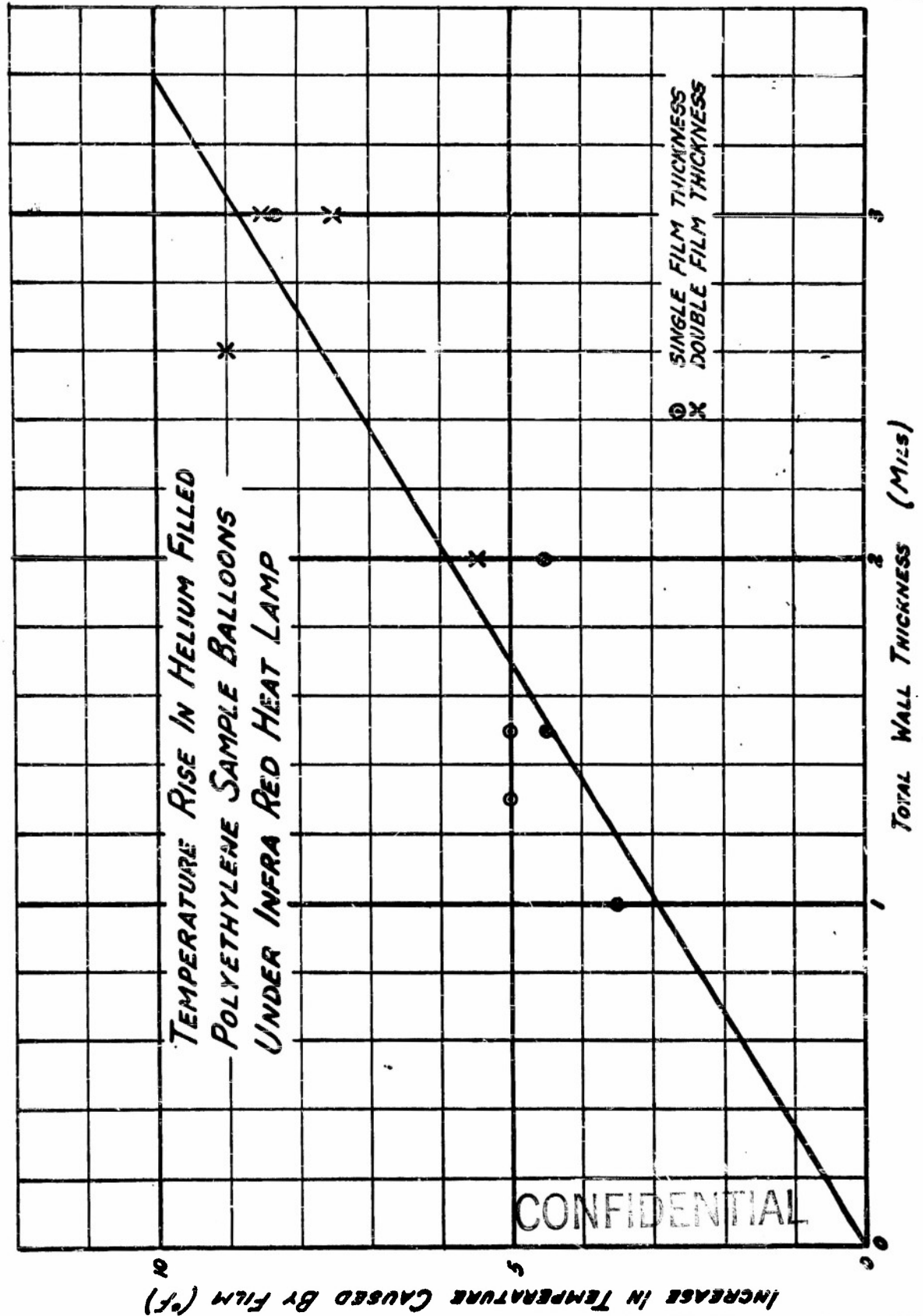
Caused by Film



CONFIDENTIAL

CONFIDENTIAL

FIG. 3



CONFIDENTIAL

2. Flight

a. Telemetering of super-pressure

In addition to altitude (ambient pressure), which will be telemetered on all flights, the first flights, which will be launched 3 hours before sunrise, will telemeter the pressure difference between the inside and the outside of the balloon. With an experiment like this on the first flight of each balloon type, it is hoped that the maximum super-pressure to be expected will be determined, as well as the portion of that pressure resulting from free lift. It will then be possible to evaluate the importance of a pressure relief valve or other mechanism to relieve the excessive free lift. If 5% free lift can give a suitable rate of rise, there should be no need for exhausting any gas.

After a successful flight of this first type, the next flights will telemeter the same data but will be launched 3 hours before sunset and will be expected to provide the critical data concerning balloon performance during the transition from day-time flight to night-time flight.

b. Later flights will telemeter the temperatures from three vertically arranged points within the balloon, and a fourth point in the ambient air. These experiments will be used to examine any temperature measurements with thermistors in a gas subjected to radiation. The pressures obtained in the first experiments will make possible a calculation of the temperature which should have produced them. The thermistors are expected to be thrown off by the radiation which they themselves absorb. With the pressure data, it should be possible to determine how far the thermistor's reading deviates from the real gas temperature under these conditions.

c. Accompanying either of these types of flights, a 25 ft. open-appendix balloon will, on appropriate occasions, telemeter the radiant flux being encountered by the balloons under different conditions of cloud and terrain.

d. With the combined data from these experiments, the calculations of elastic and tensile properties of the balloon materials can be verified and corrected if necessary.

CONFIDENTIAL

CONFIDENTIAL

IV. FINANCES

The total of funds committed as of 21 March 1954 was \$8,041. Of this amount, \$5,698 was labor and burden.

CONFIDENTIAL

CONFIDENTIAL

APPENDIX

CONFIDENTIAL

CONFIDENTIAL

## TEMPERATURE MEASUREMENTS ON FLIGHT 1108

The purpose of the flight was to make temperature measurements at three different levels in the atmosphere at night. Temperature elements were placed on the upper and lower side of a flat surface in order to obtain qualitative data on the effects of terrestrial radiation.

### BALLOON AND LOAD SYSTEM

A 25 foot balloon was used in the test. At the base of the balloon were two ballast gondolas and the control instruments. A 6 megacycle pressure telemetering transmitter was suspended below the ballast equipment and a 40 megacycle temperature telemetering equipment was suspended at the end of the load train approximately 100 feet from the balloon. Figure I shows the arrangement of the components.

After launching, the balloon rose to its ceiling of 24,300 ft. and floated at that level for 20 minutes. Following this, a ballast material consisting of coarse steel shot was allowed to flow from one of the ballast containers. The ballast was discharged at a rate of 6 pounds per minute and the quantity discharged was approximately 100 pounds. The balloon rose to a new level of 36,700 feet where it floated for 23 minutes. After this interval, approximately 60 pounds of ballast was discharged from the second ballast container at a rate of 12 pounds per minute causing the balloon to rise to a final ceiling of 47,750 feet. After floating at the final level for 48 minutes, the flight was terminated and the equipment descended by parachute. The ballast drops and

CONFIDENTIAL

CONFIDENTIAL

the termination were actuated by an electrical sequence timer. Temperature readings were taken during the entire flight including a major portion of the descent.

#### SENSING ELEMENTS

Weather Bureau type thermistors were used. They are designated as ML-376/AM and their body color is brown. Four thermistors were placed in cylindrical brass containers 1 1/4 inches in diameter and 2 inches in length. The cylindrical surfaces were of brass tubing (.025 inch wall) and the end pieces were of .018 inch brass. A hole was drilled in the center of one end of each container with a number 60 drill. The thermistors were located along the axis of each cylinder. Two of the cylinders were painted white and two were painted a flat black.

#### LOCATION OF SENSING ELEMENTS

Two of the thermistor cylinders, one black and one white, were placed on the underside of a sheet of Styrofoam. The remaining two were placed on the top side of the Styrofoam sheet. Figure II shows the arrangement of the thermistor housings. The unit was suspended by its leads 11 feet below the 40 megacycle transmitter. A fifth thermistor, exposed to free air, was located half way between the transmitter and the Styrofoam assembly. It was intended that only the lower pair of the housed thermistors would be exposed to direct terrestrial radiation. The Styrofoam served as a thermal barrier. The thermistors were numbered as follows:

Thermistor no. 1 In black housing on lower side of Styrofoam barrier.

Thermistor no. 2 In white housing on lower side of barrier.

CONFIDENTIAL

CONFIDENTIAL

Thermistor no. 3 In black housing on upper side of barrier.

Thermistor no. 4 In white housing on upper side of barrier.

Thermistor no. 5 In free air.

#### LAUNCHING

The flight was launched from the University of Minnesota airport on March 2, 1954 at 0156 CST. The surface temperature was  $-8^{\circ}\text{C}.$ , the wind was approximately 8 knots from the north. The sky was entirely clear.

#### RESULTS

The thermistors on the lower side of the barrier were consistently warmer than those on the upper side. This was true at all three levels indicating that the main source of radiant energy was below these levels. This is contrary to information from one source which stated that only a very small portion of the nocturnal outgoing flux originated at the surface of the earth itself and that the main radiation occurred from water vapor layers in the region of the tropopause.

The black and white housings on the lower side of the barrier were at essentially the same temperatures. This is due to the fact that the reflection coefficients of black and white paints are equal (.33) for infra red. For the visible range, the reflection coefficient for white paint is as high as .93.

At the first floating level, 24,300 feet, the lower thermistors were nearly  $10^{\circ}\text{C}.$  warmer than the top; at the next level of 36,700 feet,

CONFIDENTIAL

CONFIDENTIAL

the lower thermistors were as much as  $12^{\circ}\text{C}$ . warmer; and for at least a portion of the time at the top altitude level of 47,750 feet, the difference was as high as  $14^{\circ}\text{C}$ . It should be remembered that, in spite of the fact that the balloon seemed to float at constant levels, there might be sufficient random turbulences to cause convection effects to appear. These would tend to counteract differences caused by radiation effects. During the intervals in which the system is rising or falling, the curves tend to converge. In the latter portion of the final floating interval, there are some altitude disturbances which seem to correlate with the temperature variations for the corresponding time.

On the top of the barrier, the white thermistor housing was consistently warmer than the black. This was probably caused by the better radiating property of the black.

During the latter part of the final interval referred to above, both of the upper housings began to get warmer; the white housing warming considerably more than the black. During this same interval there was no such rise in the temperatures of the lower housings; in fact, there was even a slight reduction. The warming of the upper elements during this time is somewhat puzzling; it may conceivably be an effect of approaching sunrise. At any of the three levels, the thermistors on the upper side of the Styrofoam barrier apparently are at a lower temperature than the surrounding air, while those on the lower side of the barrier are warmer. This is shown by the fact that, when the balloon was rising, the convection caused a rise in the temperatures of the upper elements and a reduction in the temperatures of the lower elements.

CONFIDENTIAL

CONFIDENTIAL

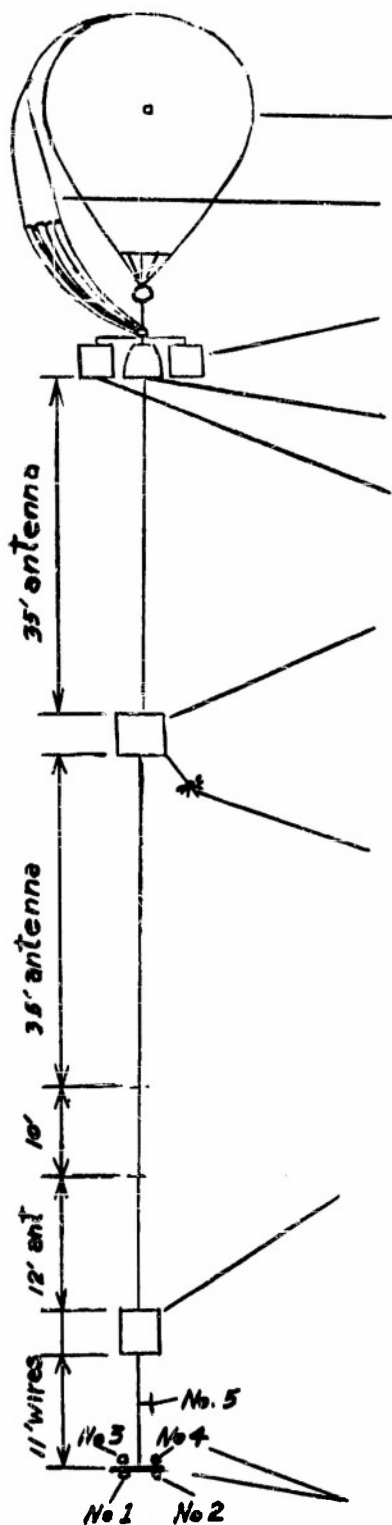
The equipment used on this flight gave only qualitative results. The sensing elements used were quite insensitive compared to such detectors as thermopiles or lead sulfide cells. It was shown, however, that the effects of nocturnal radiation are substantial and a program of investigation using thermopiles calibrated in absolute values of radiant flux would be very rewarding. As far as is known, the sky was everywhere clear along the path of this flight, and the ground was clear of snow. A series of flights conducted under various conditions of cloud cover and over various surfaces, such as dry land, snow, and water, might be of great value in explaining the adverse behavior of night-launched balloons that has been observed.

CONFIDENTIAL

CONFIDENTIAL

FLIGHT 1108

TEMPERATURE TEST



251-B Balloon 19.5 lbs.

24 foot Parachute 9.0

Ballast Gondola #1 106.8

Instrument Bag 9.0

Ballast Gondola #2 59.2

6 Megacycle altitude telemetering transmitter 17.0

Light

40 Megacycle temperature telemetering transmitter

Thermistors

13.5  
234.0 Gross load  
30.0 Free lift  
264.0 Gross Lift

FIGURE I

CONFIDENTIAL

CONFIDENTIAL

PLACING OF TEMPERATURE SENSING ELEMENTS

ON FLIGHT 1108

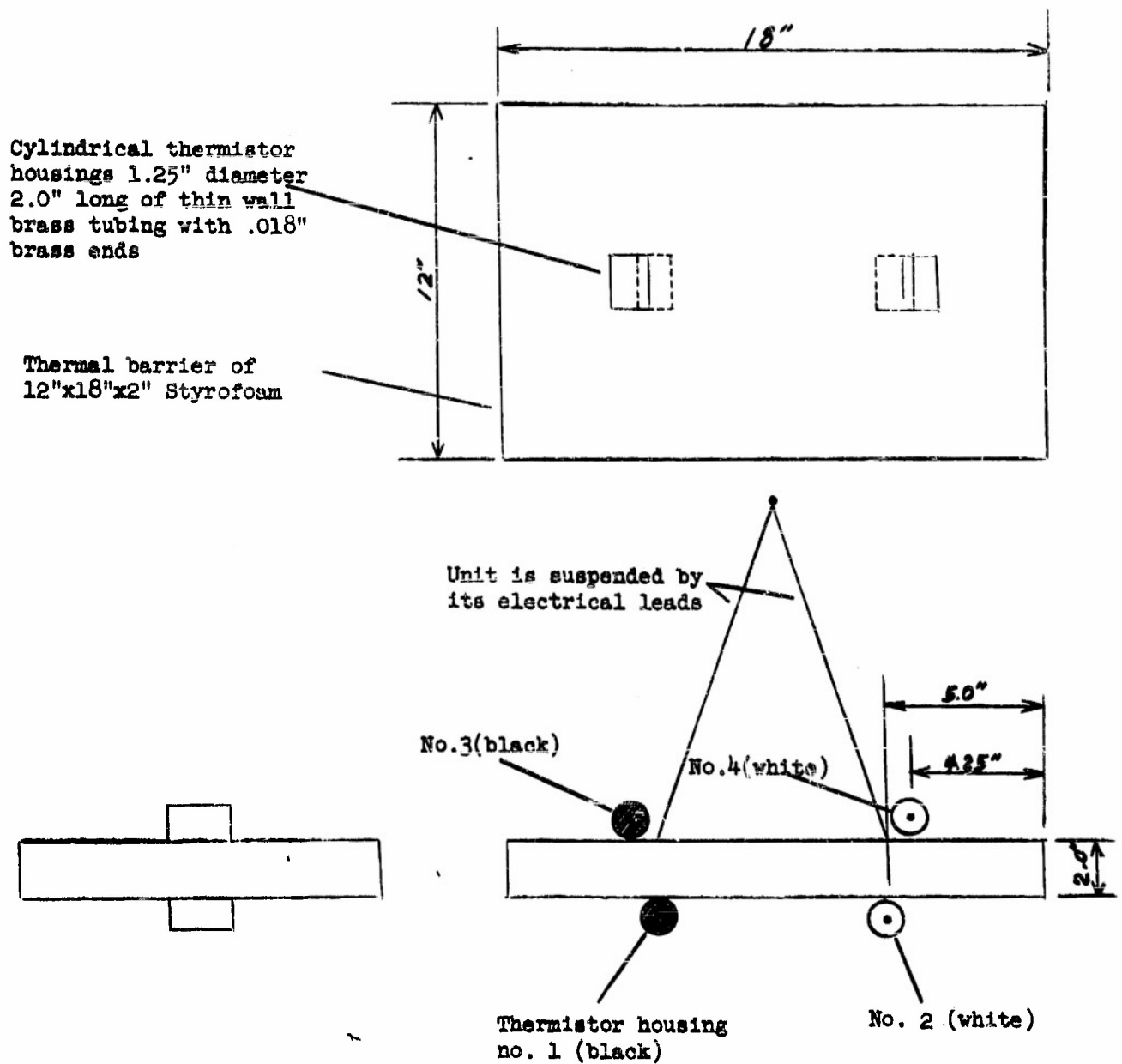


FIGURE II

CONFIDENTIAL

0200

0230

10  
20  
30  
40  
50  
60

TEMPERATURE IN DEGREES CENTIGRADE

ALTITUDE IN THOUSANDS OF FEET

◻ THERMISTOR NO.  
+ THERMISTOR NO.  
△ THERMISTOR NO.  
x THERMISTOR NO.  
◉ THERMISTOR NO.

◉ GMI ALTITU  
6420 KCS.

56 L  
AT A

RATE OF RISE  
FROM 24,300 FT  
TO 36,250 FT  
615 FT./MIN.

104 LBS. OF STEEL SHOT DROPPED  
AT A RATE OF 6.5 LBS./MIN.

RATE OF RISE  
TO 23,900 FT.  
780 FT./MIN.

1

ELAPSED TIME IN HOURS

CENTRAL STANDARD TIME

0200

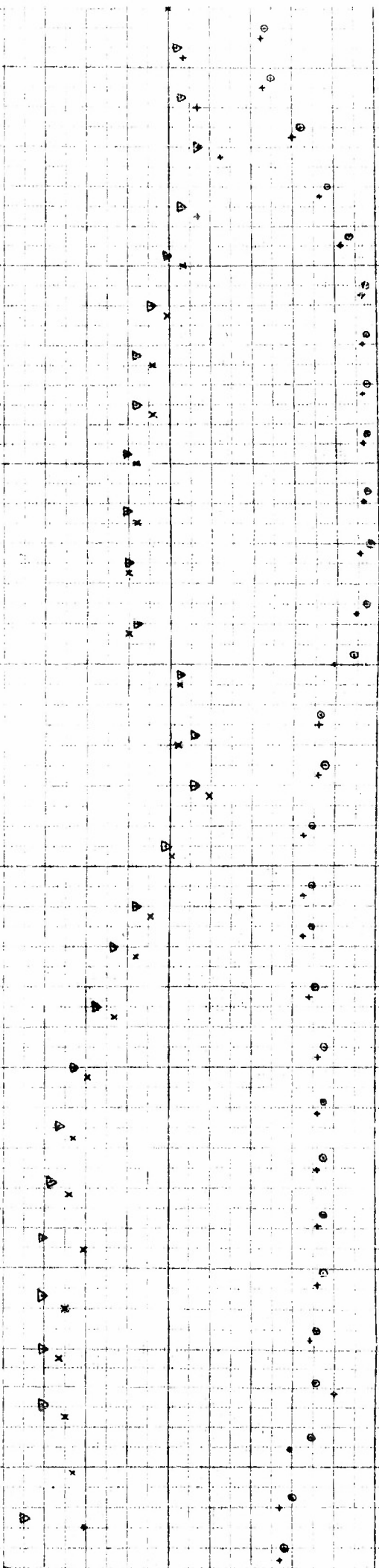
0230

0300

0330

0400

- NO. 1 IN BLACK HOUSING ON LOWER SIDE OF STYROFOAM BARRIER
- NO. 2 IN WHITE HOUSING ON LOWER SIDE OF STYROFOAM BARRIER
- NO. 3 IN BLACK HOUSING ON UPPER SIDE OF STYROFOAM BARRIER
- NO. 4 IN WHITE HOUSING ON UPPER SIDE OF STYROFOAM BARRIER
- NO. 5 IN FREE AIR



TUDE BEACON  
S. CODESONDE

RATE OF RISE  
FROM 37600 FT  
TO 46700 FT  
1075 FT/MIN.

LBS OF STEEL SHOT DROPPED  
A RATE OF 12 LBS/MIN.

LAUNCH SITE, UNIV OF MINN. AIRPORT  
0156 CST 2 MARCH 54

1.5

2

0300

0330

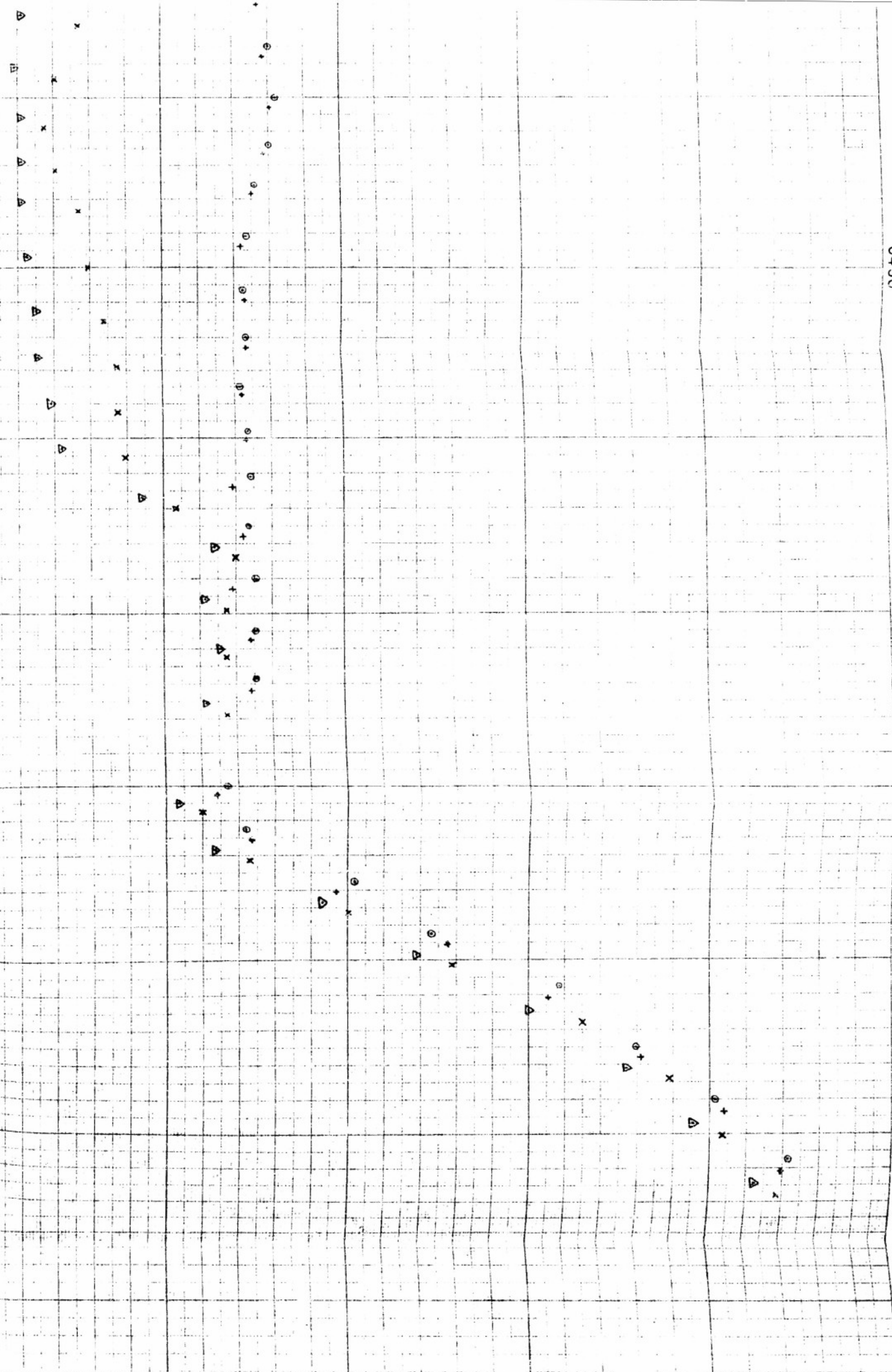
0400

2

0430

0500

0530



FLIGHT NO. 1108  
FLOWN 2 MARCH 54  
FOR 8-5024  
LOAD ON BALLOON 2145 LBS.  
FREE LIFT 30 LBS. = 12.0 %  
BALLOON TYPE NUMBER WEIGHT  
251B 79 195 LBS.

FLIGHT TERMINATED BY TIMER  
AT 0442

3

FLIGHT ON  
AT 0552.5

2.5

3

3.5

0430

0500

0530

ELAPSED TIME IN HOURS

CENTRAL STANDARD TIME

0500

0530

CONFIDENTIAL

TEMPERATURE IN DEGREES CENTIGRADE

FLIGHT NO. 1108  
FLOWN 2 MARCH 54  
FOR 8-5024  
LOAD ON BALLOON 2145 LBS.  
FREE LIFT 30 LBS. = 12.8%  
BALLOON TYPE NUMBER WEIGHT  
251B 79 195 LBS.

TERMINATED BY TIMER

PRESSURE IN MILLIBARS

FLIGHT ON GROUND  
AT 0532.5

3-8-54 RJWK  
APPROVED *LJK*

4

CONFIDENTIAL

500  
400  
300  
200  
150  
100  
50  
0

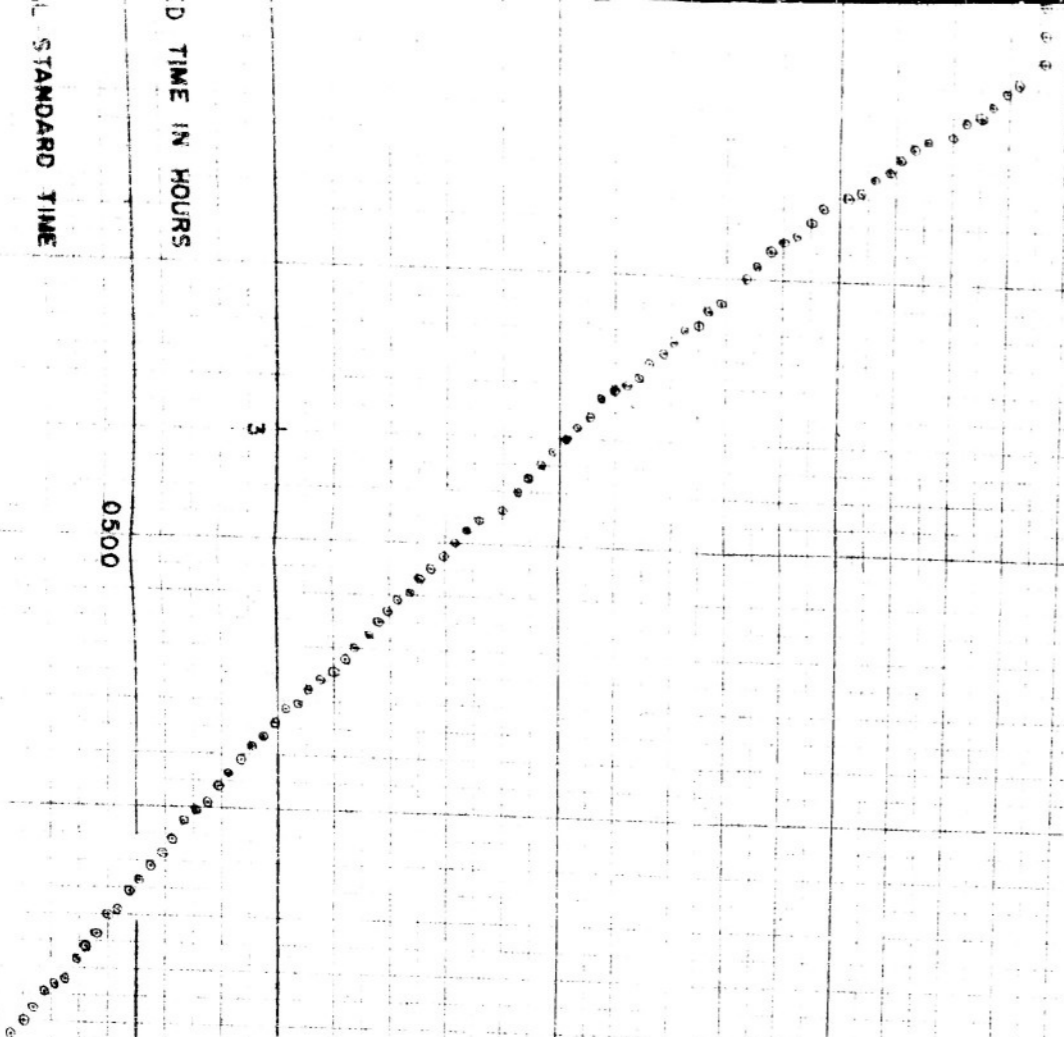
0530

3.5

0500

STANDARD TIME

D TIME IN HOURS



MAY 4 1954